INVESTIGATING THE CAUSAL RELATIONSHIP BETWEEN ENERGY CONSUMPTION AND ECONOMIC GROWTH IN NIGERIA

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ABSTRACT
This study investigates the causal relationship between energy consumption and economic growth in Nigeria for the period of 1981-2018. Total energy consumption is disaggregated into four subcategories (i.e., electricity power consumption, fuel pump price, energy capital formation, coal energy consumption) in an attempt to examine whether the links between energy consumption, and economic growth differs among the various sources of energy consumption. The study after conducting unit root test and cointegration employs granger causality test. The results of unit root test and cointegration test show that all variables are stationary at first difference, while there exist long run relationship among the variables in the model respectively. The granger causality result revealed the absence of bi-directional causality between the energy consumption variables and growth. This means that causality does not run from energy consumption to economic growth as well as economic growth to energy consumption. Apparently, there is empirical evidence of unidirectional causality between Elect_P and GDPg not in reverse direction. In general, it can be safely concluded that there is an evidence of a long-run causality between energy consumption variables and growth in Nigeria but run from energy consumption variables (electricity power consumption) to economic growth. This result lends support to the electricity-growth hypothesis in Nigeria. It is therefore recommended that government should encourage more access to energy diversifications and consumption as a primary source of value for factors of production i.e. labor and capital which we cannot do without.

Keywords: Energy Consumption, Economic growth, Causality, Nigeria
JEL Classification: Q37, Q43, Q47

1. INTRODUCTION

The pioneering work of Kraft and Kraft (1978) triggered the interest in the energy consumption-growth debate. Since then, the debate has been extended to specific areas such as the electricity-growth nexus, clean energy-growth, energy-environment and other related issues (Usman et al 2020; Ogbebor and Ashakah, 2021; Musa et al 2021; Usman et al 2019 and Iorember et al 2022). Until this point in time, the energy consumption and economic growth debate had produced conflicting and interesting outcomes. Previous research on this debate was widely conducted for countries in Latin America, the Caribbean and Asia; however, few concentrated on the countries in Sub Saharan Africa (Ogbebor and Ashakah, 2021; Odhiambo, 2009); and Nigeria's case has been even less researched.

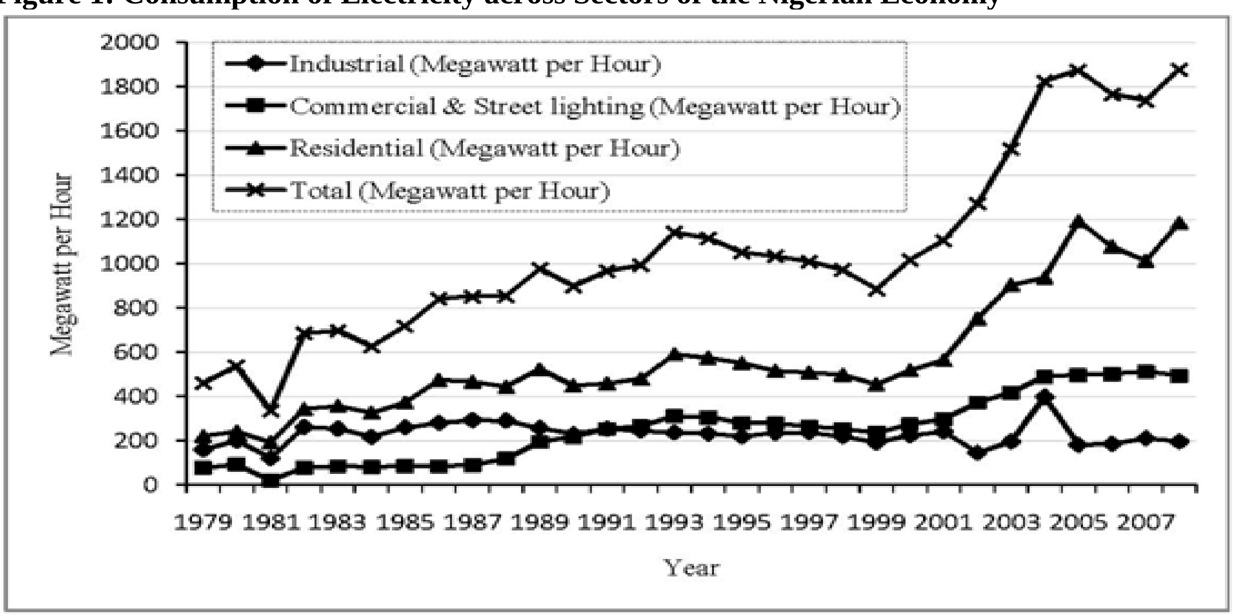
The responsibility of production and distribution of electricity was saddled with the National Electric Power Authority (NEPA), established by decree no. 24 of 1972 until recently when the sector was deregulated in order to allow private participation. The NEPA was charged with the statutory monopoly power to over-see electricity development throughout the country and produce electricity under a high proportion of in-operational generating plant capacities of 27%, overloaded and overstretched transmission lines; in addition, the problem of hydrological inadequacies in hydro-electric plants especially within the period of dry season. The foregoing challenges coupled with illegal access to transmission lines have culminated into frequent breakdown of electricity equipment (seemingly due to overload) and a large quantum of electricity losses in the transmission system (ranging between 20-30%), NEPA often responded to these anomalies by creating an electricity supply-demand artificial balance such as rationing, shedding and suppressed demand services; all these have resulted in the low quantum of electricity available for consumption. This current status of electricity supply in Nigeria reflects a situation of supply crisis in which industrial growth and socio-economic development paces are kept below the potential of the economy (Ayodele, 2001).

According to Nigerian Electric Power Authority (NEPA), the Niger Dam has the maximum capacity to generate 5,900 megawatts of electricity per day which falls far below the average national consumption rate of 10,000 megawatts per day. This has compelled NEPA to ration electric power supply over the years. The inability to satisfy the domestic and, to a large extent, industrial needs for electricity is reported to have had debilitating impact on the growth potentials of the Nigerian economy (World Bank, 1991; Igbinedion et al 2022).

Even so, the demand for electricity, according to NEPA, is projected to increase from 5,746 megawatts in 2005 to nearly 297,900 megawatts by the end of 2030. This implies that NEPA needs to add approximately 11,686 megawatts of electricity to its stock each year to match this projection. Electricity consumption per capita has been rising over the years, except for a few dips (i.e. in 1981, 1984, 2001, 2006, and 2009). As a result, since 1971; electricity consumption per capita increase from 28.49 kWh/person to 153.93 kWh/person in 2012 (Zhang and Broadstock; 2016).

Nigeria with a population of over 180 million people is endowed with enormous energy resources, such as, petroleum, natural gas, coal, nuclear, tar sand. Others include solar, wind, biomass and hydro. However, development and exploitation of such energy sources have been skewed in favor of the hydro, petroleum, and natural gas. At independence in 1960, agriculture was the dominant sector of the economy contributing about 70%. This trend changed with the discovery of oil in 1970. The exploitation of the Nigerian energy resources began with coal in 1916. There are nearly three billion tons of indicated reserves in seventeen identified coalfields and over 600 million tons of proven reserves in Nigeria (Oji et al, 2012).

Figure 1: Consumption of Electricity across Sectors of the Nigerian Economy



Source: Ogundipe, 2019.

Following the Nigerian civil war, many coal mines were abandoned, and coal production never completely recovered. This is evident by coal production levels becoming erratic as both the resuscitation and maintenance of imported mining equipment proved troublesome (Godwin, 1980). As a result, coal production dropped insignificantly from 50% in 1960 to less than 1% in 1990. This decline in coal production was hastened by the discovery of crude oil in commercial quantities in Otuabagi / Otuogadi, Oloibiri district in Bayelsa state by Shell Darcy on 15 January 1956. Between 1970 and 1980, petroleum products were cheap and readily available as premium motor spirit (PMS) otherwise known as petrol assumed the role of main source of energy in Nigeria. As a result, all other energy sources were neglected (Adejola et al. 2022; Oji et al. 2012).

With proven oil reserves exceeding 9 billion tons, Nigeria is one of the largest hydrocarbon feedstock producers in Africa and ranks twelfth place worldwide. The country relies heavily on its petroleum industry for economic growth, the sector accounts for about 80% of government revenues and provides 95% of foreign exchange (Iwu, 2008). Nigeria is a member of the Organization of Petroleum Exporting Countries (OPEC) with natural gas reserves account for 5.2 trillion cubic meters; making it the world's seventh biggest natural gas reserve. Although, natural gas occurs in associated form with crude oil, Nigeria's gas reserves are three times greater than its oil reserves. The government is committed to increasing gas production for domestic supply as well as for export evident by The Trans-Saharan Gas Pipeline currently in development. This will enable Nigeria to supply the continent of Europe with gas. The country provides 10% of the world's LNG (Corporate Nigeria, 2012). Despite this potential, gas flaring has continued unabated over the years (Eboh, 1998).

Currently, the Nigerian energy crisis has stymied the socio-economic activities of the country which has brought untold hardship on the people of the country. Now, the electricity supply in the country does not meet national demand. While the estimated daily power generation was about 3,700MW as of December 2009, the peak load forecast for the same period was 5,103MW. This is based on the existing connections to the grid which does not consider the suppressed demand. Also, the projected electricity demand has been translated into demand for grid electricity and peak demand on the bases of assumptions made for transmission and distribution losses, auxiliary consumption, load factor and declining non-grid generation (Energy Information Administration, 2012). The demand is projected to rise from 5,746 MW in 2005 to 297,900MW in the year 2030 which translates to construction of 11,686MW every year to meet this demand (Sambo, 2008). While the government owned monopoly company (Power Holding Company of Nigeria) has been unbundled, in its stead, three hydro and seven thermal generating, a radial transmission grid (330kV and 132kV); and eleven distribution companies (33kV and below) that undertake the wires, sales, billing, collection and customer care functions within their area of geographical monopoly have been set up. Except for the transmission function, the others have been privatized.

The epileptic nature of electricity has led to scarcity of petrol and kerosene because the citizens have resulted to using generators and kerosene powered equipment to provide energy for use at homes. Also, import content of our domestic fuel usage has grown over the years to about 75% (International Energy Agency, 2012).

This has resulted in the use and over dependence on fuel-wood which has led to deforestation and attendant degradation of the environment and worsening desertification (Babanyara & Saleh, 2010). They report an average annual deforestation rate of 2.38% between 1990 and 2000 in Nigeria due in part to the change to the use of wood fuel as a result of hikes in prices of kerosene and cooking gas. Other alternative energy sources including solar, wind, wave is largely underdeveloped in the country. Furthermore, as a result of domestic fuel prices which have gone up several times with attendant upsurge in transport fare and prices of goods and services; Bamikole (2012) reports that industrial capacity utilization has plummeted from 78.7% in 1977 to 30.1% in 1987 before resurgence to 53.3% in 2007 and 53% in 2010.

Evidence shows that there are available literature on the electricity consumption and economic growth debate (Ahmed and Habiba, 2022; Lee, 2005; Wolde-Rufael; 2006 & Akinlo, 2008). Besides, most of these studies suffer from two main limitations: a) Omission-of variable bias, when testing for causality within a bivariate VAR (see Ikye 2015) over-reliance on cross-sectional data to explain country-specific issues. Granger causality in either a bivariate or multivariate context has been the dominant econometric approach. This is followed by innovation accounting that employs impulse response function or forecast error variance decomposition within the framework of error correction model (ECM).

Perhaps, affected by the choice of methodology, selectivity bias, data quality and specification issues, the findings have produced conflicting results. While some of the studies have reported unidirectional causality from energy to growth (Adenikinju, 1998, Odularu and Okonkwo, 2009, Onakoya et al., 2013; Usman and Idris, 2022), others found causality from growth to energy (WoldeRufael, 2005 and 2009; Akinlo (2009), bi-directional causality (Chontanawat et al. 2008; Omisakin, 2008) and statistical independence (Usman et al. 2020; Mustapha and Fagge, 2015). The motivation for the revisit of the relationship between energy consumption and economic growth is two-fold. Insights have been offered by the existing studies under the implicit assumption of a constant econometric framework which ignores the possibility of structural break in the relationship. Hence, this study investigates the causal relationship between energy consumption and economic growth in Nigeria for the period of 1981-2018. Therefore, this paper is divided into five sections which are; Introduction, empirical review, methodology, empirical analysis and, conclusion and recommendations.

2. EMPIRICAL REVIEW

The literature on energy consumption and economic growth is quite broad and continues to expand. Gozgor, et al (2018) analyzed the effects of renewable and non-renewable energy consumption on the economic growth in the panel data of 29 Organization for Economic Co-operation and Development (OECD) countries for the period from 1990 to 2013. For this purpose, the paper considers the panel autoregressive distributed lag (ARDL) and the panel quantile regression (QPR) estimations. The paper finds that not only the economic complexity but also both the non-renewable and renewable energy consumption are positively associated with a higher rate of economic growth.

Wei-wei (2020) sums up the evaluation and literature on energy consumption and economic growth at home and abroad, thinks "southern talk" as the energy consumption and economic growth in the time division, makes a series of empirical tests on the relationship between total energy consumption and economic growth in China from 1978 to 1991 and from 1992 to 2016. The results show that total energy consumption is a one-way causal relationship between economic growths in china. Economic growth has a strong dependence on energy; there is a co-integration relationship between energy consumption and economic growth. However, economic growth depends on energy consumption decreased year by year in China.

Fang and Chang (2016) consider the K-L model (augmented production function) in the energy-growth nexus, and their paper is the first to include the human capital into the empirical model. Using the panel unit root and the panel co-integration tests that capture the effects of cross-sectional dependence, they find that the economic growth causes the energy consumption in the panel dataset of 16 Asia Pacific countries over the period 1970 to2011.

Okorie, et al (2016) examined the causal relationship between electricity consumption and economic growth in Nigeria for the period of 1980 to 2014. The study employed the analysis of Johansen co-integration and VAR-based techniques. A long-run relationship exists among the variables. The result shows that in the long run, electricity consumption has a similar movement with economic growth, following the positivity hypothesis. The Granger causality test reveals that there is a unidirectional causal relationship between electricity consumption and economic growth.

Olayeni (2016) investigates the asymmetric effect in the energy-growth nexus. Using the data for real GDP per capita and energy consumption per capita over the period 1971-2008, He examined the relationship for 12 sub-Saharan African countries employing a hidden co-integration approach. For Gabon, Nigeria and Côte d'Ivoire, the results show that their growth rates could be adversely affected by conservation policies. However, for Benin, Kenya, and Sudan, the results show that conservation policies could enhance the growth process in these countries. We also find instances of policy dilemmas for Nigeria and Benin that conform to both the growth and the conservation hypotheses.

Alshehry and Belloumi (2015) assessed the dynamic causal relationships between energy consumption and economic growth in Saudi Arabia. By using the Johansen multivariate co-integration approach, the findings have indicated that in the long-run there exists a relationship between energy consumption and economic growth. The unidirectional causality runs from energy consumption to economic growth and carbon emissions, bidirectional causality runs among the carbon emissions and economic growth. In the short-term, there is a unidirectional causality that runs from carbon emissions to energy consumption and economic growth.

Long, et al (2015) examined the relationship between economic growth and energy consumption, in case of China from 1952 to 2012. Estimations have indicated that coal has dominant effect on economic growth and bidirectional causality runs from economic growth to carbon emission, gas consumption, coal consumption and electricity consumption.

Bernard and Obi (2016) examined the causal relationship between economic growth and energy consumption in Nigeria during the period 1980-2012 and employed the co-integration test, OLS analysis, error correction model and pairwise granger causality test techniques. The co-integration test result revealed that there was a long-run relationship between our variable of interest. The study found that electricity is an important factor in economic growth in Nigeria. The result is thus an indication that energy consumption enhances economic growth enormously. Furthermore, the result from the causality test shows that there is a bi-directional causal relationship between total energy consumption and economic growth in the long run.

Lin (2014) investigates the short-run and long-run causality between renewable energy (RE) consumption and economic growth (EG) in nine OECD countries from the period between 1982 and 2011. To examine the linkage, He uses the autoregressive distributed lag (ARDL) bounds testing approach of cointegration test and vector error-correction models to test the causal relationship between variables. The co-integration and causal relationships are found in five countries—United States of America (USA), Japan, Germany, Italy, and United Kingdom (UK). The overall results indicate that a short-run unidirectional causality runs from EG to RE in Italy and UK; long-run unidirectional causalities run from RE to EG for Germany, Italy, and UK; a long-run unidirectional causality runs from EG to RE in USA, and Japan; both long-run and strong unidirectional causalities run from RE to EG for Germany and UK; and finally, both long-run and strong unidirectional causalities run from EG to RE in only USA. Further evidence reveals that policies for renewable energy conservation may have no impact on economic growth in France, Denmark, Portugal, and Spain.

Al-Mulali, Fereidouni, Lee, Sab (2013) examine the renewable energy-growth nexus in 108 countries for the period from 1980 to 2009, and they find that there is bidirectional causality between the renewable energy and the economic growth in 85 of 108 countries. They used the FMOLS and the panel smooth transition VECM estimations.

Ogundipe (2013) examined the relationship between electricity consumption and economic growth in Nigeria using the Johansen and Juselius Co-integration technique based on the Cobb-Douglas growth model covering the period 1980-2008. The study adopted and also conducted the Vector Error Correction Modelling and the Pairwise Granger Causality test to empirically ascertain the error correction adjustment and direction of causality between electricity consumption and economic growth. The study found the existence of a unique co-integrating relationship among the variables in the model with the indicator of electricity consumption impacting significantly on growth. Also, the study shows evidence of a bi-directional causal relationship between electricity consumption and economic growth

In this study, we attempt to shed more light on the intricate and complex causal relationships energy consumption and economic growth by accounting for the shortcomings in the existing literature. Thus, our contributions can be summarized as follows. First, we build a very comprehensive dataset of energy consumption and economic growth consisting of 37 years covering the period 1981-2018. Second, we disaggregate total energy consumption into four subcategories (i.e., electricity power consumption, fuel pump price, energy capital formation, coal energy consumption) in an attempt to examine whether the links between energy consumption, and economic growth differs among the various sources of energy consumption.

3. METHODOLOGY

3.1 Model Specification

Following the theoretical framework and the work of Akpan and Akpan (2012), and considering the conventional production function (Y), where capital stock (K) and labor (L) are the main inputs. As presented in the theoretical background, energy as a factor of production, entered exogenously. By including energy consumption (EC) factors, the production function could be augmented as below:

$Y = f(K, EC, L,)$ ……………………………………………………………………..1

The Cobb-Douglas production function form of equation 3.1 is written as;

$Y = A(K^a . EC^b . L^c)$ ……………………………………………………………… 2

Where; a, b, c, are respectively output elasticity to changes in capital, energy consumption factors and labor. The above is 'compositely' transformed thus to accommodate dynamism of growth process:

$Y_{it} = A_{it} + X'_{it}\beta + \mu_{it}$ ……………………………………………………………………..3

$lny(t) = lnA + \alpha lnk(t) + clnL(t) + Aln(EC)^{1-\alpha-c}$……………………………………4

where; log(y) represents gross domestic product (growth), log(k) represents capital stock i.e. gross capital formation driven by energy capital, Log(EC) represents energy consumption indicators to include: electricity power consumption, fuel pump price, energy capital formation, coal energy consumption, $Log(L)$ represents per capita income a measure of welfare or wellness of labour capital (HDI) and ε is the error term naturally assumed to be IID with zero mean and constant variance. As a result, equation 3.6 will be estimated indirectly (ILS) on energy consumption $ln(A^e)$.

3.2 Technique of Analysis

Unit Root Test

The techniques of unit root test such as the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests are considered appropriate as preliminary tests before the estimation of the model. This enables us to avoid the problems of spurious result that are associated with non-stationary time series models. Without a recourse to structural break unit root tests as used by Dabwor et al (2022); Goshit et al (2022), the current study relies on the non-structural breaks units roots tests of ADF and PP in estimating the stationarity properties of the series.

Co-integration Estimate

This is employed to determine the number of co-integrating vectors using Johansen's methodology with two different test statistics namely the trace test statistic and the maximum Eigen-value test statistic. The first one tests the null hypothesis that the number of different co-integrating associations is less than or equal to 'r' in contradiction to the alternative hypothesis of more than 'r' co-integrating associations, and is defined as:

$$\theta_{trace}(r) = -T \sum_{j=r+1}^{P} 1n\left(1-\hat{\theta}_j\right) \quad 5$$

The maximum Eigen-value statistic is used for testing the null hypothesis of at most ‘r’ co-integrating vectors alongside the alternative hypothesis of ‘r+l ‘co-integrating vectors, is given by:

$$\theta_{\max}(r,r,+1) = -T\,1n\,(1-\hat{\theta}_{r+1}) \quad 6$$

Where = the eigen values, T = total number of observations. Johansen argues that, trace and statistics have nonstandard distributions under the null hypothesis, and provides approximate critical values for the statistic, generated by Monte Carlo methods.

In a situation where Trace and Maximum Eigenvalue statistics yield different results, the results of trace test should be preferred.

Granger Causality

The standard Granger causality testing (Granger, 1969) is used to identify the possibility of a causal relationship between the variables. The test approaches the question of whether past values of Y can predict future values of another variable E, for stationary series, I(0). Depending on the presence or lack of cointegrated relationships, the procedure takes place in a VAR or a VECM framework.

In the absence of cointegration, the linear Granger causality testing is constructed in a VAR. The mathematical representation of the model is given as follows:

$$Y_t = \sum_{i=1}^{l} a_i Y_{t-i} + u_t \quad 7$$

where Y_t is the vector of all the endogenous variables, l is the selected number of lags, a_i are the matrices of coefficients to be estimated, and u_t the error term that is assumed to be serially uncorrelated with zero mean and constant variance.

Particularly, for a bivariate model, the following regression is taking place:

$$Y_t = a_0 + a_1 Y_{t-1} + \cdots + a_l Y_{t-1} + \beta_1 E_{t-1} + \cdots + \beta_l E_{t-1} + \varepsilon_t \quad 8$$

$$E_t = a_0 + a_1 Y_{t-1} + \cdots + a_l Y_{t-1} + \beta_1 E_{t-1} + \cdots + \beta_l E_{t-1} + u_t \quad 9$$

The test to find whether E Granger causes Y (or Y causes E) is a test of the joint hypothesis for the lagged coefficients:

$$\beta_1 = \beta_2 = \ldots = \beta_l = 0 \quad (10)$$

And the alternative is that at least one is different from zero. The null hypothesis of no Granger causality can be rejected if the alternative is proven. To sum up, the Granger causality test can rise to the following conclusions: (i) E causes Y, but Y does not cause E; (ii) Y causes E, but E does not cause Y; (iii) E causes Y and vice versa; and (iv) neither Y causes E nor E causes Y. In cases (i) and (ii), unidirectional causation is running, and in case (iii), the causality is bidirectional. Lastly, the last conclusion does not indicate a causal relationship between Y and E. The lag length, l, corresponds to the beliefs of the length of time over which one variable can help predict the other.

Nature and Sources of Data

Time series data are used for this study spanning from the year 1981-2018. The data on gross domestic product (GDP) and energy consumption indicators: measured in megawatts per hours of electricity, carbon dioxide emissions in millions metric, crude oil production in barrel per day, coal energy consumption, and control variables as gross capital formation and income per capita were obtained from the CBN statistical Bulletin, 2018 and World Development Index (WDI), 2019 respectively.

4. RESULT PRESENTATION AND DISCUSSION

4.1 Descriptive Statistics

Descriptive statistic is used to describe the main features of the data set which include measures of central tendency (mean, median, and mode); measures of variability (standard deviation, variance); the minimum and maximum values of variables (kurtosis and skewness) providing summary of samples and observations which forms the basis for the description of the data set.

Table 1 Summary of Time-series Descriptive Statistics Results

	GDPG	COAL_C	CRUDE	EGCF	ELECT_P	P_PF	TRADE
Mean	4.888486	2.807822	9.225114	30.38883	0.960839	0.316316	4.702775
Median	5.161929	2.793827	9.271997	28.62620	1.027209	0.390000	4.701758
Maximum	15.32916	4.789672	11.45259	53.18669	1.566462	0.620000	4.990360
Minimum	-2.035120	0.717509	5.939302	14.90391	-0.331970	0.020000	4.250901
Std. Dev.	4.211794	0.949160	1.747087	12.29717	0.419959	0.225739	0.176532
Skewness	0.354909	-0.133072	-0.323212	0.232321	-1.363746	-0.108975	-0.267355
Kurtosis	2.941904	3.110996	1.989521	1.806100	4.919832	1.398764	2.796078

Source: Researcher's Computation, 2021

Table 1 shows that GDPg has an average of 4.8884 and a std. dev. value of 4.211. This means that the GDPg has a wide deviation as supported by the max. and min. values of 15.33 and -2.035. With a positive skewness value of 0.354 and platykurtic value of 2.94, it implies an increasing GDPg trend with fewer occurrences of major fluctuations within the period of observations. Also, the EGCF has an average and std. dev. of 30.3888 and 12.2917 which implies that there has been a notable increase in energy gross capital formation over the years with a max and min. values of 53.1866 and 14.90 respectively. EGCF is positively skewed with a value of 0.2323 and also has a platykurtic value of 0.86 that equally suggests the occurrence of major distortions during the study period. Furthermore, P_Pf shows a mean value of 0.1316 as well as a std. dev. value of 0.2257. Clearly, this indicates that the pump price of gasoline otherwise known as petrol has increased significantly. This is further confirmed by the wide range between its max. and min. values of 0.62 and 0.02 US dollars. Fuel pump price has a negative skewness value of -0.1089 and a platykurtic value of 1.398 that indicate that the occurrence of major fluctuations; truly impactful though, negatively. The coal consumption (caol_C) has a mean and std. dev. values of 2.8078 and 0.949 respectively. This suggests that the coal_c has increased relatively within the research period as further revealed by its max. and min. values of 4.789 cubic feet and 0.7175 respectively. With a negative skewness value of -0.13307 and leptokurtic value of 3.14, it suggests that there has been a mild rise in consumption of coal in Nigeria. The CRUDE shows a mean and std. dev. values of 9.225 and 1.7471; indicating that there has been much deviation of CRUDE from its mean. This suggests that CRUDE utilization or exploration has increase noticeably over the year as shown its max. and min. values of 11.4525 and 5.9393 respectively. CRUDE is negatively skewed with a value of -0.3232 and a platykurtic value of 2.58. Lastly, the ELE_P has an average and std. dev. of 0.9608 and 0.4199 which implies that there has been a notable increase again in the volume of electricity consumption over the years with a max and min. values of 1.566 and 0.33 respectively. ELE_P is negatively skewed with a value of 1.3637 and also has a platykurtic value of 4.91 that equally suggests the occurrence of major increase during the study period.

4.2 Stationarity (Unit-Root) Test

The study commences it empirical analysis by first ascertaining the unit roots of the time series to be used for analysis. This is important because most time series exhibit non-stationarity traits in their level form, which often poses a serious problem to econometric analysis and may therefore lead to spurious result if appropriate measures are not taken.

Table 2: Unit-Root Test Result

Variable		@ level	@ first difference	Equation Specification	Order of integration
RGDP	ADF	-2.025024 (0.2749)	-4.494464 (0.0077)	Intercept & Trend	**I(1)**
	PP	-1.541368 (0.7881)	-4.463796 (0.0082)	Intercept & Trend	**I(1)**
EGCF	ADF	-1.542351 (0.7878)	-4.064202 (0.0195)	Intercept & Trend	**I(1)**
	PP	-1.714282 (0.7158)	-4.039328 (0.0205)	Intercept & Trend	**I(1)**
P_PF	ADF	-2.184486 (0.0049)	-4.465284 (0.0086)	Intercept & Trend	**I(0)**
	PP	-2.313794 (0.4125)	-4.591887 (0.0062)	Intercept & Trend	**I(0)**
TRADE	ADF	-1.969711 (0.5798)	-6.272446 (0.0004)	Intercept & Trend	**I(1)**
	PP	-3.694441 (0.0417)	-9.401434 (0.0000)	Intercept & Trend	**I(1)**
CRUDE	ADF	-3.619126 (0.0485)	-5.078996 (0.0023)	Intercept & Trend	**I(1)**
	PP	-2.605855 (0.2423)	-6.889486 (0.0000)	Intercept & Trend	**I(1)**
COAL_C	ADF	-3.619126 (0.0485)	-5.078996 (0.0023)	Intercept & Trend	**I(1)**
	PP	-2.715855 (0.2423)	-6.829486 (0.0000)	Intercept & Trend	**I(1)**
ELE_P	ADF	-3.619126 (0.0485)	-5.078996 (0.0023)	Intercept & Trend	**I(1)**
	PP	**-2.705855 (0.2423)**	**-6.889486 (0.0000)**	**Intercept & Trend**	**I(1)**

P-values at 5% statistical significance

Source: Researcher's Computation

To guard against spurious result, this study takes the step in checking the properties of the variables with the use of the Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1981) and the Phillip-Perron (PP) test developed by Phillips and Perron (1988). The results are presented in Table 2. With respect to the ADF test on Table 2, all the variables were found to be non-stationary in their level but were stationary after first differencing (that is, the variables are integrated of order one) implying that the variables are I(1) series. The result of the ADF test result is supported by the PP test result. However, the PP result showed a superior result when the values are compared. Therefore, this suggest that all the variables are integrated of order one i.e. they are all I(1s). This outcome satisfies the condition for conducting cointegration test which requires that all the variables must be integrated of the same order either at first difference or higher difference. Hence, the next sub-section presents the results for the cointegration test. After identifying the order of integration in levels and at first difference using both ADF and PP test, the results from the two-unit root tests suggested that the long run relationship among the variables may exist. Therefore, it is very appealing to investigate if the individual variables of interest can actually converge in the long run. To investigate this, the study employed Johansen Multivariate Cointegration technique.

4.3 Johansen Co-integration Test

The basic idea behind co-integration is that if in the long- run; two or more series move closely together, even though the series themselves are trended, the difference between them is constant. It is possible to regard these series as defining a long-run equilibrium relationship, as the difference between them is stationary (Hall and Henry, 1989). A lack of co integration suggests that such variable have no long-run relationship: in principal they can wander arbitrarily far away from each other (Dickey et al, 1991).

Table 3: Johansen Multivariate Cointegration Test (Trace)

Trend assumption: Linear deterministic trend

Series: GDPG EGCF P_PF TRADE CRUDE COAL_C ELE_P

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.787568	99.97622	69.81889	0.0000
At most 1 *	0.743080	61.24794	44.85613	0.0023
At most 2	0.525777	27.27318	20.79707	0.0311
At most 3	0.231382	8.621225	15.49471	0.0030
At most 4	0.078440	2.042184	3.841466	0.0010

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
*** denotes rejection of the hypothesis at the 0.05 level**
****MacKinnon-Haug-Michelis (1999) p-values**

Source: Researcher's Computation, 2021

We employ the maximum likelihood test procedure established by Johansen and Juselius (1990). To identify the long run relationship among the included variables, the Johansen (1988) multiple cointegration test has been employed by using a lag length of one year suggested by Schwarz Information Criterion (SIC) criteria. From Table 3, it can be observed that both the Trace test and Maximum Eigenvalue test rejected the first null hypothesis at 1% level of significance, implying presence of one cointegrating equation among the variables. Specifically, the trace test statistics indicates the existence of one cointegrating equation, and likewise the maximum Eigenvalue statistics reveals the same at 1% level of significance in both cases. It is therefore concluded that there is long-run relationship among the variables.

4.4 Causality Test

It is the aim of this study to determine the causal relationship between disaggregated energy consumption components (indicators) and economic growth in Nigeria. In other words, is it the energy consumption that causes economic growth or vice versa? Hence, the electricity-led economic growth, or growth-driven energy consumption, feedback and/ or neutrality hypotheses as the case may be. To do this, the Granger causality test was carried out between the disaggregated energy consumption components (indicators) and economic growth (GDPg) in Nigeria. The null hypothesis underlying the Granger causality test is that the variable under consideration does not Granger-cause the other while the alternative is that it Granger-causes it. The results of the Granger causality test are reported in Table 4.4.

Table 4: Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	**Prob.**
EGCF does not Granger Cause GDPG	27	0.50398	**0.6116**
GDPG does not Granger Cause EGCF		14.8558	**0.0099**
P_PF does not Granger Cause GDPG	27	1.96253	**0.1666**
GDPG does not Granger Cause P_PF		1.63355	**0.2202**
ELE_P does not Granger Cause GDPG	27	0.94511	**0.0025**
GDPG does not Granger Cause ELE_P		8.22008	**0.4367**
TRADE does not Granger Cause GDPG	27	0.39854	**0.6765**
GDPG does not Granger Cause TRADE		3.07137	**0.0687**

NB: * means rejection of the null hypothesis of non-Granger causality.

Source: Researcher's Computation, 2020

The results in Table 4 show the Granger causality test between energy disaggregated consumption indicators and economic growth in Nigeria. It is instructive to point out here that the cointegration test carried out earlier indicate the existence of a long run relationship between variables but say nothing about the direction of the causal relationship. Execution of the Granger causality test makes it possible for us to determine the direction of the relationship. In the Granger causality approach, causality exists if the F-statistic is statistically significant given its associated probability value. Thus, in this study, causality is established up till 5% level. The results therefore, revealed the absence of bi-directional causality between the energy consumption variables and growth. This means that causality does not run between the main researches variables in vice-versa. Apparently, there is empirical evidence of unidirectional causality between Elect_P and GDPg not in reverse direction. In general, it can be safely concluded that there is an evidence of a long-run causality between energy consumption variables and growth in Nigeria but run from energy consumption variables (electricity power consumption) to economic growth. This result lends support to the electricity-growth hypothesis in Nigeria.

5. CONCLUSION AND RECOMMENDATIONS

This study investigates the causal relationship between energy consumption and economic growth in Nigeria for the period of 1981-2018. Total energy consumption is disaggregated into four subcategories (i.e., electricity power consumption, fuel pump price, energy capital formation, coal energy consumption) in an attempt to examine whether the links between energy consumption, and economic growth differs among the various sources of energy consumption. The results revealed the absence of bi-directional causality between the energy consumption variables and growth. This means that causality does not run from energy consumption to economic growth as well as economic growth to energy consumption. Apparently, there is empirical evidence of unidirectional causality between Elect_P and GDPg not in reverse direction. In general, it can be safely concluded that there is an evidence of a long-run causality between energy consumption variables and growth in Nigeria but run from energy consumption variables (electricity power consumption) to economic growth. This result lends support to the electricity-growth hypothesis in Nigeria. It is therefore recommended that government should encourage more access to energy diversifications and consumption as a primary source of value for factors of production i.e. labour and capital which we cannot do without.

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